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Department of Agriculture and Biosystems Engineering

South Dakota Water Resources Institute

WATER NEWS

South Dakota State University

North Central Region tackles harmful algal blooms

Faculty researchers from the South Dakota Water Resources Institute and SDSU Extension are part of the North Central Region Water Network project that seeks to educate the public and promote research about harmful algal blooms, or HABs.

Learn more about HABs

Algae pull nutrients from swine facility manure, air

Researchers are investigating the use of algae to reduce phosphorus in the liquid waste streams from swine units to make field application easier—and, perhaps, to remove carbon dioxide and ammonia from indoor and exhaust air.

Learn more about the algae research

Study examines woodchip quality in bioreactors

A team of SDSU engineering researchers is evaluating the efficiency of fresh and weathered woodchips in bioreactors..Very little research has been done on how woodchip quality affects nitrate removal.

Read more about the woodchip study

Nonprofit joins battle to mitigate Lake Mitchell algal blooms

A newly organized nonprofit, The Friends of the Firesteel Creek, is working with the city of Mitchell and other organizations to implement changes that will decrease algal blooms in Lake Mitchell.

Learn more about algal mitigation efforts

Take a look at the virtual 2020 Eastern South Dakota Water Conference

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Water Resources Institute, 1400, N Campus Drive, Room #221, Brookings, SD 57007

North Central Region tackles harmful algal blooms

BY CHRISTIE DELFANIAN | MARCH 22, 2021

South Dakota State University faculty researchers from the South Dakota Water Resources Institute and SDSU Extension are part of the North Central Region Water Network project that seeks to educate the public and promote research about harmful algal blooms. (Photo courtesy of Eugene Braig)

Blue-green algae toxins are deadly. An animal that drinks contaminated water dies in less than 24 hours.

Ranchers typically find the dead animal beside a contaminated stock dam, explained SDSU Extension Cow/Calf Field Specialist Robin Salverson. However, by the time the cause of death is determined, the blue-green algae toxins may have dissipated. “It can come and go so quickly in some cases, but in others, it (harmful algal blooms) can be more persistent.”

Warm weather, calm condition, sunlight and ample nutrients—nitrates and phosphorus—in the water create ideal conditions for algal blooms, which typically occur in late summer and early fall. However, “the variation

can be baffling," noted Salverson, pointing to an instance in which "algal blooms affected water in pasture with no fields for miles."

That's why South Dakota State University faculty researchers from the South Dakota Water Resources Institute and SDSU Extension are part of the North Central Region Water Network project that seeks to educate the public and promote research about harmful algal blooms, or HABs. The project brings together faculty from the state water resources research centers and cooperative extension offices at the Northern Central Region's land grant institutions. U.S. Geological Survey is also a partner on the HAB project.

The resources that the Algal Bloom Action team is developing will be useful tools to educate South Dakotans about harmful algal blooms, according to SDSU Extension Water Resources Field Specialist David Kringen. He is the SDSU representative for the project, serving on the subcommittee developing written documents, such as fact sheets.

"Many states are dealing with harmful algal blooms and we can tackle these issues much better together than we can individually," Kringen said.

Pooling resources

During the October 2020 Eastern South Dakota Water Conference, Amy Weckle, Illinois Water Resource Center program manager, and Hanna Bates, acting assistant director of the Iowa Water Center, described the HABs project, which began in 2018. After taking an inventory of the available literature, the team identified gaps in Extension and outreach as well as research recommendations for the region.

The team subdivided the project into five areas: general knowledge about HABs; identifying, monitoring and treating HABs; human health and HABs; animal health and HABs; and landscape nutrient management. The community engagement and outreach materials will be designed for many audiences—municipalities, lakefront property owners, rural and urban residents and farmers, as well as federal and state agencies, municipalities and the private sector.

Some species of algae form long chains, clinging to rocks and sediment in ponds. (Photo courtesy of Frank Gibbs)

Furthermore, the HABs team identified Extension as "a change agent that can bring this information to audiences to empower these communities," Bates said.

Kringen said, "As outreach material is developed by the HABs team, we will let people know where the information is available."

Advancing research

Strengthening HABs research is also one of the North Central Region Water Network's goals. An inventory of water resources research center-funded research in the North Central Region showed that between 2014 and 2017, 30 projects related to HABS received more than $2 million in federal and matching funds. Fifteen of those projects focused on prediction and source detection. Only two were about animal health.

In January, the HABs team, now known as the Algal Bloom Action Team (ABAT) hosted its first annual research symposium and, in March, a series of six every-other-month webinars will begin. More information on HABs events will be posted at https://northcentralwater.org/habs/.

Social media and public service announcements will provide information to specific audiences and the team is preparing short videos as teaching tools. “We will update these outreach materials as the research becomes available,” Bates said.

In her role advising South Dakota producers, Salverson emphasized the need to “bring everyone up to speed on this area and what can be done to help manage it.” However, she noted, when it comes to mitigation and control, “based on my understanding of managing blue green algae in dams, what we can do is pretty limited and is not always effective. More research in this area would be beneficial.”

Because you cannot tell whether toxins are present just by the presence of algae, Kringen’s advice is simple: “If you see algae, be it red, green, blue or pink, keep pets, livestock and people away from the water.”

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Algae pull nutrients from swine facility manure, air

BY CHRISTIE DELFANIAN | MARCH 22, 2021

Swine manure is a rich source of nutrients, but its high phosphorus content in comparison to the other nutrients the crop needs means only so much can be spread on a field.

Doctoral student Augustina Osabutey pulls sample of the algae-swine manure mixture from the photobioreactor.

Professor Gary Anderson of SDSU's Department of Agricultural and Biosystems Engineering is investigating the use of algae to reduce phosphorus in the liquid waste streams from swine units and make field application easier. In addition, he also hope to utilize the algae to remove carbon dioxide and ammonia from indoor and exhaust air.

"Swine waste contains higher quantities of phosphorus than the crop needs relative to the other nutrients. If we can remove some of the nutrients, primarily phosphorus, we can have a product that producers can spread on their fields without having to use other supplemental fertilizers," Anderson explained. Furthermore, the phosphorus harvested from the manure mixture could be sold as separate product.

In addition, removing the nutrient pollutants from indoor air will improve the quality of air released from the swine facilities and help reduce the odor.

Assistant professor Xufei Yang of the Department of Agricultural and Biosystems Engineering, lecturer Kyungnan Min of the Department of Civil and Environmental Engineering as well as agricultural and biosystems engineering doctoral student Augustina Osabutey are also working on the project.

The research is supported by U.S. Department of Agricultural Hatch funding through the South Dakota Agricultural Experiment Station.

“Basically, we are treating nutrient waste streams to get a neutral product,” Anderson said. “The goal is to take something we have trouble utilizing correctly and make it into a value-added product that will enable producers to reduce or eliminate the costs of the manure processing system.”

Experimenting with algae-manure mixture

“Algae is a biological system of removing nutrients,” explained Anderson, who been working on the project since 2018. The nutrients in the swine manure are used to grow the algae, thereby capturing the phosphorus. When harvested, the algae can be dried and used as a phosphorus supplement.

The algae is grown in a photobioreactor, a closed vessel with a light source. Getting light to penetrate the solution is one of the problems the researchers must overcome.

“Algae need light, so we approach that by reducing the solids in the swine waste, diluting the mixture and using higher intensity light,” Anderson explained. The research team is currently doing lab-scale batch processing using 5- to 20-liter systems.

The researchers obtain swine waste from the SDSU Swine Research Facility and then determine the pH, chemical oxygen demand, total suspended solids and the level of nitrogen, ammonia, nitrate, nitrite and phosphorus in the manure.

“Once we know what the waste contains, we decide on the dilution ratios,” Anderson said. Liquid containing algae at a specific concentration is then added to the photobioreactor and processed for 14 to 21 days. During that time, the researchers pull samples at specific intervals to evaluate how nitrogen and phosphorus levels, chemical oxygen demand and suspended solids are changing and to measure algae biomass production.

Currently, the researchers are using an algae species that readily consumes ammonia, but other high-value species, such as those that can be used to produce biodiesel and jet fuel, can also be evaluated in future testing.

Improving air quality

In addition to using nutrients from the manure, the researchers have also examined using the ammonia and carbon dioxide present in air from the manure pit to grow algae in the photobioreactor.

“A pump pulls the air through a tube that runs about 12 inches below the floor slats, thus drawing in the most contaminated air,” Anderson explained. The manure pit is underneath the floor slats.

The air moves through a filter that removes dust and then through the sparger, which injects or bubbles the gas into the photobioreactor’s water and algae mixture. In addition to the carbon dioxide becoming available to the algae, the ammonia also ionizes in

Doctoral student Augustina Osabutey, left and assistant professor Xufei Yang determine the chemical oxygen demand in a swine waste sample. The higher the oxygen demand, the greater the amount of phosphorus and ammonia.

the water producing ammonium which is the nitrogen source preferred by algae, Anderson explained.

In 2018 and 2019, visiting scientist Seyit Uguz, who is working on his doctorate at Uludag University in Turkey, designed and tested a photobioreactor system that uses nutrients from the swine facility air to grow algae. He ran the system at SDSU's swine facility for three weeks collecting data on carbon dioxide and ammonia consumption as well as algae growth.

Though Anderson and Uguz are still analyzing the data, the results are encouraging. "First, nothing in the hog house killed the algae," Anderson said. "Second, filtering the dust eliminated any plugging issues in the sparger, and third, the algae was consuming the carbon dioxide and ammonia from the hog house air and the biomass was increasing."

After the air bubbles through the photobioreactor, it can be exhausted or, after removing moisture from the air, can be recirculated into the building during the winter, Anderson explained. "Recirculating the warm air (in the winter) will help save energy costs."

If the results from the liquid manure experiments are promising, Anderson hopes to combine the two systems this summer. The combined system has the potential to reduce waste management costs through the harvesting of value-added products.

SDSU study examines woodchip quality in bioreactors

BY CHRISTIE DELFANIAN | FEBRUARY 22, 2021

Doctoral student Abdoul Aziz Kouanda of SDSU's Department of Civil and Environmental Engineering pulls water samples from a column reactor to determine the nitrate removal rates of fresh woodchips and those subjected to three different types of weathering—sunlight alone, soil and water/moisture and natural outdoor conditions.

Draining excess water from fields is good for agricultural production, but the nutrient-laden water flowing through the drainage tile can pollute nearby water bodies. Diverting the water through an underground chamber filled with wood chips, known as a woodchip bioreactor, can help remove nitrates and thereby reduce the environmental impact on creeks, streams and lakes.

"Bacteria that grow on the woodchips degrade the nitrates," explained South Dakota State University associate professor Guanghui Hua, who has been doing research on woodchip bioreactors since 2014.

Though woodchip bioreactors have been used for several decades, most of the research has focused on performance parameters, such as reactor size, water temperature, water flow and nitrate removal rates.

Very little research has been done on the quality of woodchips, Hua explained. “Many things can occur before the woodchips are put into the reactor. The chips can be exposed to sunlight, moisture, bacteria or even fungi —the woodchip quality can be changed by the natural weathering process.”

Hua, professor Chris Schmit and lecturer Kyungnan “Karen” Min of the Department of Civil and Environmental Engineering are evaluating the efficiency of fresh and weathered woodchips for bioreactors. The research is supported by the U.S. Geological Survey 104B Grants Program administered through the South Dakota Water Resources Institute and an in-kind match from the Department of Civil and Environmental Engineering. Doctoral student Abdoul Aziz Kouanda is also working on the project.

Testing weathered versus fresh woodchips

The researchers obtained fresh cottonwood and oak woodchips from a Sioux Falls supplier and then subjected portions of the woodchips to different types of weathering for five months. One batch of was exposed to sunlight alone, another was composted with soil and water/moisture and the final one was subjected to natural outdoors conditions.

To compare the performance of the fresh and weathered woodchips, the researchers ran simulated drainage water through a column reactor and then evaluated the nitrate removal rates. “We use the same flow rate for the column reactors to achieve a flow through time of 12 hours, which is a typical bioreactor time,” Hua explained. The continuous flow column testing, which began in October, will be completed by March.

Overall, the weathered woodchips performed better than the fresh woodchip sample, Hua reported. “The natural weathering process can enhance the bioreactor efficiency for nitrate removal. That’s encouraging because natural storage is practical.”

Furthermore, Hua said, “we found solar-treated woodchips perform better than naturally weathered chips and the naturally weathered chips are better than the composted woodchips.”

Kouanda filters the samples from the column reactor before analyzing how much nitrogen has been removed.

Evaluating wet-dry cycling

Generally, a woodchip bioreactor is most efficient immediately after installation. “Over time, the woodchips lose organics, the food source for the bacteria that remove the nitrates, so the efficiency declines,” Hua explained. The greatest decline occurs the first year and then slows.

In the bioreactor, water constantly flows through the woodchips. Hua and his team are evaluating whether using wet and dry cycles can change the quality of the organics and therefore help stabilize the removal rates. That would mean using control gates to stop the flow of water through the woodchips in the bioreactor at specific intervals.

To test this concept, the researchers will use fresh cottonwood chips and ones that have been prepared using the three different weathering conditions. Using the bioreactor column, they will start and stop flows of simulated drainage water at intervals ranging from several days to a week and then determine the nitrate removal rates.

Previous studies at other universities have shown that the wet-dry cycling can improve the bioreactor's efficiency, Hua noted. He hopes to complete this portion of the project this summer.

Nonprofit joins battle to mitigate Lake Mitchell algal blooms

BY CHRISTIE DELFANIAN | MARCH 22, 2021

Algal blooms have plagued Lake Mitchell due to high nutrient levels in the lake, but new mitigation efforts include creating wetlands upstream to capture nutrients and building a low-head dam to prevent sediment and phosphorus from entering the lake. (Photo courtesy of Kyle Croce, Public Works Director for the City of Mitchell)

Lake Mitchell has a long history of algal blooms.

The reservoir, built in 1928, was once a source of drinking water for the city of Mitchell and recreation for the community. However, by the 1990s, algal blooms increased due to nutrients accumulating in the lake. By 2003, the city stopped using the lake as its sole source for drinking water.

Part of the problem is that the 350,000-acre Firesteel Creek Watershed drains into the 693-acre lake. “A 40:1

radio of watershed acres to lake area can be problematic—the ratio for Lake Mitchell is 500 to 1," explained Paula Mazzer, an assistant professor of chemistry at Dakota Wesleyan University and board member of the newly organized nonprofit, Friends of Firesteel Creek. Mazzer described ongoing collaborative projects to address the problem at the October 2020 virtual Eastern South Dakota Water Conference.

"Upstream producers have taken advantage of state and federal opportunities to improve runoff, so each individual producer is contributing very little," said Mazzer, estimating spring runoff is down to 0.14 to 0.26 pounds of phosphorus per acre per year. "That's not too bad, but it's such a huge watershed."

Battling phosphorus

Additions of alum in 2003, 2004 and 2005 reduced the lake's phosphorus levels to 600 parts per million. However, by the end of each summer, the lake had returned to its previous phosphorus level. During the last three years, the phosphorus level has been around 1,400 ppm. More than 100 ppm is severely eutropic, meaning there is not enough oxygen for aquatic life.

In 2015, a consulting firm found 47% of the phosphorus in the lake is trapped in the sediment, known as internal loading. Furthermore, an analysis of the sediment showed that "instead of iron III, which traps phosphorus well, up to 17% of the phosphorus is bound to iron II, which releases phosphorus easily," she explained. "As soon as the phosphorus level in the lake starts to drop, the iron II releases phosphorus."

Last year's lower flow levels resulted in decreased phosphorus levels on the upstream input to the lake after mid-June, but the levels in the center of the reservoir and at the spillway rebounded, reflecting the high internal loading.

Building wetlands

A recent engineering study recommended creating wetlands to capture nutrients and dredging the lake as well as continuing watershed conservation efforts. The Friends of the Firesteel Creek nonprofit is working with the city of Mitchell and other organizations "to implement a version of this plan," Mazzer said. That includes raising funds for the work that needs to be done and providing information to help people understand how these projects can help restore the lake. More information on the nonprofit is available at www.FriendsoftheFiresteel.org

In January 2019, Mitchell purchased 371 acres of land to build wetlands upstream of the Highway 406 bridge. The city has also applied for a $5 million National American Wetlands Conservation Act grant to support the project, according to a Feb. 25 Mitchell Daily Republic article.

In May 2019, a senior design team from South Dakota State University's Department of Agricultural and Biosystems Engineering recommended building a low-head dam to prevent sediment and phosphorus from entering the lake. The city is now working with the U.S. Department of Agriculture Natural Resources Conservation Service, Ducks Unlimited, Pheasants Forever and the James River Water Development District to construct the dam.

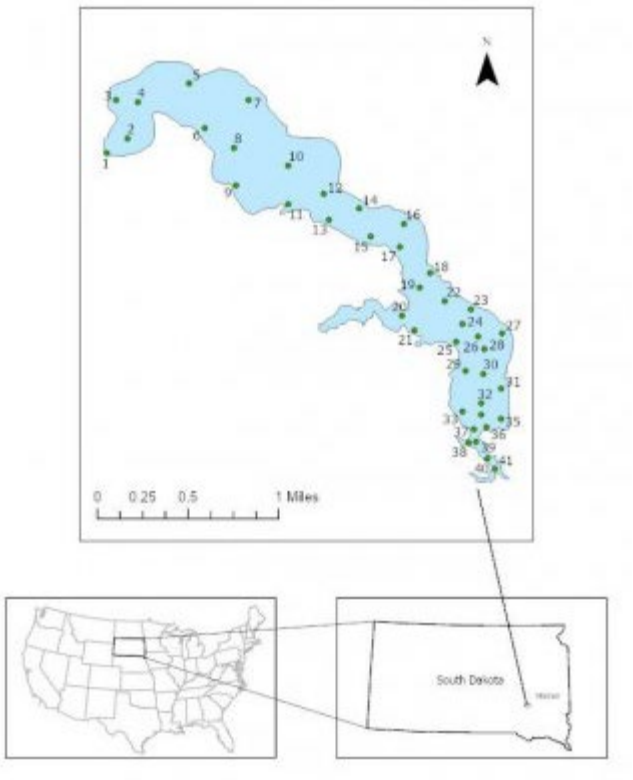
SDSU Extension Water Resources Field Specialist David Kringen said, "A low-head dam will spread the water across the property, decrease flow velocity and allow for sediment deposition before reaching Lake Mitchell. The team also recommended that a multistage riser be incorporated into the dam to help manage flow rates." Rather than water simply flowing over the top of the dam, the risers will allow water to flow through the dam at various stages.

Monitoring algal growth

Other SDSU faculty are doing research to connect the amount of algae with other water quality parameters, according to assistant professor John McMaine, who now leads the project. “We want to be able to monitor the extent of algae and blue-green algae concentration using a list of variables, including dissolved oxygen, temperature, turbidity, fluorescent dissolved, organic matter and nutrient levels.”

The project was begun by former assistant professor Rachel McDaniel, now an adjunct faculty member, and also involves biology and microbiology professor Bruce Bleakley. The research is funded by the U.S. Geological Survey 104B Small Grants Program administered through the South Dakota Water Resources Institute and an in-kind department salary match.

Last summer, SDSU researchers collected data at an average of 70 locations within the lake five times between July and October. That data will allow them to understand how the measured water quality parameters are changing through four dimensions: spatially across the lake, within the water column, and over time. Master’s student Sumit Kumar Ghosh is working on this part of the project.



On July 20, 2020, SDSU researchers gathered data to monitor the extent of algae and blue-green algae concentration at 40 points in Lake Mitchell. Water quality measurements were taken five times during summer 2020 at an average of 70 locations in the lake.

In addition, McMaine and the team are trying to tie the measured chlorophyll-a data to remote sensing data from the European Space Agency’s Sentinel 2 satellite, launched in 2015, which has spatial resolution of 10 to 20 meters, depending on the spectral band.

“Instead of going out in a boat, you can use remotely sensed data to track algal blooms through time,” McMaine explained. “It will be a cost-effective tool that gives a more complete picture of the extent of algal blooms in the lake.” This tool will also help monitor the impact mitigation efforts, such as the wetlands and dam, are having on algal growth that will then improve the lake’s water quality.

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Related Departments

2020 Eastern South Dakota Water Conference

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"Water's Lasting Legacy: Informing the Future with Lessons from the Past"

Wednesday, October 14, 2020

Due to the COVID-19 outbreak, the conference was entirely on-line.

A recording of the conference is available:

CONFERENCE RECORDINGS

A copy of the conference agenda is available here:

CONFERENCE AGENDA

Featured Speakers:

Merger of the South Dakota Department of Agriculture and South Dakota Department of Environment and Natural Resources

Jeanne Goodman
Director of Environmental Services
SD Department of Environment and Natural Resources

Brian Walsh
Public Affairs Director
SD Department of Environment and Natural Resources

Partnering to Develop Research, Outreach, and Education Resources to Mitigate Harmful Algal Blooms in the North Central Region

Amy Weckle
Program Manager
Illinois Water Resources Center (IWRC)

Hanna Bates
Acting Assistant Director
Iowa Water Center (IWC)

The Statewide Ground Water Quality Monitoring Network Information System

Tim Cowman, State Geologist & Program Administrator
Geological Survey Program
SD Department of Environment and Natural Resources

NRCS Assisted Watershed Dams – History, Condition of Structures, Rehabilitation and DamWatch

Brett Pettigrew, P.E.
USDA Natural Resources Conservation Service

Estimating Water Quality Lag Times using Groundwater Age

Troy Gilmore
Groundwater Hydrologist and Assistant Professor
University of Nebraska

Lake Mitchell & the Friends of Firesteel: A public/private partnership to improve water quality in the Firesteel Creek/Lake Mitchell watershed

Paula Mazzer
Associate Professor of Biochemistry
Dakota Wesleyan University
Friends of Firesteel Board Member

Investigating the Impacts of 2019 Niobrara River Dam Failure to Riparian Habitats of the Upper 39-Mile Segment of the Missouri National Recreational River

Nathan Schaepe
Hydrologist/GIS Specialist
U.S. Geological Survey, Nebraska Water Science Center

Trend Analysis: Insights, Challenges and Building Blocks

Rochelle A. Nustad
Hydrologist
U.S. Geological Survey

Climate Whiplash: Drought-Flood-Drought – Water and Agricultural Impacts from 2018-2020

Dennis Todey
Director, USDA Midwest Climate Hub
Ames, IA

Cropping Pattern Changes Diminish Agroecosystem Services in North and South Dakota

Peter O'Brien
Research Agronomist
USDA Agricultural Research Service
Ames, IA

Stay tuned for further developments!

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